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The National Education Association's systematic information program, aimed at various segments of the teaching profession, plays an important role in the dissemination of information on programed instruction. The Department of Audiovisual Instruction and the Division of Audiovisual Instructional Service have been particularly active in this information program. In the past forty years many changes have taken place in the field of audiovisual education, and terms such as "instructional technology" and "educational media" are now used interchangeably with it. Although programed instruction holds great promise for education and certainly cannot be viewed as just another audiovisual aid, it is becoming increasingly difficult in schools to separate this particular development from the broader spectrum of instructional technology. The future of instructional technology in the schools will depend significantly on the rapport and degree of communication between the scientists who are expanding the boundaries of learning theory and the educational practitioners who are practicing the art of teaching.

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Programed Instruction

Volume III, Number 1
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Programed Instruction and the Teaching Profession

The National Education Association's systematic information program, aimed at various segments of the teaching profession, plays an important role in the dissemination of information on programed instruction. Two NEA units, the Department of Audiovisual Instruction (DAVI) and the Division of Audiovisual Instructional Service, have been particularly active in this information program.

The NEA's attitude toward programed instruction was tacitly expressed in 1960 when DAVI published the well-known source book edited by A. A. Lumsdaine and Robert Glaser, *Teaching Machines and Programmed Learning*. Here for the first time was a collection of the significant work done to date in this promising field. Earlier DAVI had published the eighty-page *Teaching Machines: An Annotated Bibliography* and, a year before that, Lumsdaine's article, "Teaching Machines and Self-Instructional Materials." During this relatively early period, programed instruction was becoming a more frequent topic for discussion at national and regional meetings sponsored by the NEA and in an increasing number of articles in the more than one hundred magazines published by NEA-related (national and state education) organizations. Space does not permit an account here of NEA's expanded role in programed instruction since 1960. Let us, rather, establish a rationale for the concern of audiovisual specialists with programed instruction.

One reason for the early and continuing interest of DAVI, with its membership of six thousand audiovisual specialists, is undoubtedly the fact that the audiovisual director in many schools has historically been most concerned with adapting technological development to the teaching-learning process. Long before "audio" was added to make "audiovisual," William C. Bagley described the duties of the "visual specialist" in the April 1923 issue of *Visual Education*. Among his responsibilities in the school, said Bagley, he was "to work out graded exercises that may increase the learner's ability to 'observe and report,' to form for himself mental images and to manipulate these in his thinking, to grasp abstractions that are progressively refined, and to see essential things in larger and larger units."

In the past forty years many changes have taken place in the field of audiovisual education. In fact the term "audiovisual" may have already outlived its usefulness, for today such terms as "instructional technology" and "educational media" are used interchangeably with it. Using the tentative term, "audiovisual communications," DAVI's Commission on Definition and Terminology has recently defined the field:

> Audiovisual communications is that branch of educational theory and practice concerned primarily with the design and use of messages which control the learning process.
>
> It undertakes: (a) the study of the unique and relative strengths and weaknesses of both pictorial and non-representational messages which may be employed in the learning process for any purpose; and (b) the structuring and systematizing of messages by men and instruments in an educational environment. These undertakings include the planning, production, selection, management, and utilization of both components and entire instructional systems.
>
> Its practical goal is the efficient utilization of every method and medium of communication which can contribute to the development of the learners full potential.

Incidentally, the DAVI monograph from which the above definition was drawn contains a glossary of approximately nine hundred terms, including seven pages of definitions related to programed instruction developed by Susan Meyer Markle.

As the pressures of an expanding technological society place the audio-

(Continued on page 2)

Inside Opinion

MACHINES REVISITED

As one of the authors of a review of research comparing teaching machines and programed textbooks as presentation modes, I have found myself alternately berated and congratulated for being antimachine. As I have become increasingly aware of the potential of hardware in programed instruction, I welcome the opportunity to clarify my position.

Our review of research found "no significant differences in mastery between the machine and the programed-text forms of presentation. In those studies where time to complete the program was a recorded variable, the general finding has been that there is a time-saving feature connected with the use of programed textbooks. . . . In the light of the results obtained, and considering the problems associated with using machines in the classroom and in other teaching environments, and recognizing the equivalence in mastery and saving of time obtained with programed texts, perhaps one should ask whether the burden of proof should not now be shifted to teaching machines."

Our conclusions are only relevant to the types of studies summarized: studies dealing with **literate** subjects (the youngest were fourth graders) and standard linear programs relying on constructed responses to stationary visual stimuli. In none of the studies did the machine provide control of frame presentation or confirmation in ways the student was not able to provide for himself. For the subject matters, types of programing, and range of students in the studies we reviewed, I believe new studies would disclose similar findings: present machinery is more of a hindrance than a help.

Our findings did **not** deal with programs for preliterate subjects or with programs teaching other than verbal-written materials. For these machinery is essential.

The unique place of computerized teaching machines is being demonstrated in the work of O. K. Moore at Hamden Hall School, Ralph Grubb at IBM, and John Coulson at System Development Corporation. Computerized machines provide the programer with far greater flexibility than is available in textbook programing.

My own interest in hardware involves problems encountered in programing for preliterate children where an essential component of the behavior being taught is the making of accu-

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MACHINES REVISITED

(Continued from page 1)

rate comparisons. Here, certainly, it is necessary to have machines that do not advance until correct choices are made.

Lassar D. Gotkin
Director, Reading Improvement Project, CPI.

Antimachine attitudes are an outgrowth of the circumstances of the past five years or so. When the term "teaching machines" entered the vocabulary, it intrigued psychologists, reporters, and engineers alike. Machines received a lot of premature publicity . . . and a lot of premature machines were developed. In a study about eighteen months ago, Finn and Perrin located approximately a hundred devices that could be classed as teaching machines. Few were production-line models, and most of those that were in quantity production were of the simple write-in type that eager researchers soon proved to have no superiority over the book or notebook. Further, many of the devices (with the exception of those adapted from existing ones such as filmstrip viewers) were nightmares of design and reliability.

The consequent general belief that teaching machines were of no value was not justified at the time and is certainly not justified now. In the last eighteen months, forces have been regrouping, and different directions seem to be evident.

Since the definition of a teaching machine is by no means precise, it would be helpful to restrain preconceptions and consider, for the moment, (a) individual instruction, (b) student participation, and (c) feedback to the student. as the parameters of our discussion.

1. At the time of the Finn-Perrin survey, there was no readily available, reliable, and inexpensive Pressey-type machine. At least one is now available for programers willing to try the simple, multiple-choice approach.

2. There is increasing use in industry of the so-called performance-aid or production-prompter type of audiovisual machine which was first developed by Hughes Aircraft.

3. Most developmental work is now occurring with audiovisual machines, using slides or film strips for stimulus material and, in many cases, including sound. The old Navy rater from World War II is being revived; this device stores several programs on film strips, uses a Pressey response, and not only informs the student immediately, but times him.

4. Using sound motion pictures as stimulus material is a difficult technical problem, especially when a branching capability is desired. Several groups are working on it, and Perrin and Luxton, at the University of Southern California, have now built a machine for research purposes which will branch slides, film strips, or silent and sound motion pictures.

5. The most significant possibilities for the immediate future lie in the cartridge-loading 8 mm. film devices. Forsdale and his associates at Teachers College have developed some ingenious student-participation films (silent) at several levels (word syllabification, Chinese calligraphy, multiplication tables) which require overt response to the extent that the student must even touch the screen of the viewing box. Programers who restrict their thinking to simple Skinnerian verbal frames will have difficulty adjusting to some of these concepts. Also, cartridge-loading 8 mm. sound is here and, while not yet in the programing picture, no doubt will be before the year is out.

6. Work continues in the computer field at several centers across the country, including at least two new ones, with new, highly sophisticated developments in the offing.

Some of these devices will be free-standing, containing their own logic and stimulus material and not operating as slaves to a central computer. None of the computer experiments, incidentally, confines its stimulus material to the pure verbal type.

7 The language laboratory—now often referred to as the electronic learning laboratory—has always had a teaching-machine capability, and this is increasingly being exploited. In some places, visual capabilities are being added. One manufacturer now markets a sound film-strip viewer with total stop-and-go control of the record, automated answer tape, and provision for audio participation which is a sort of small language laboratory and teaching machine in itself.

8. Finally, the group feedback devices (classroom communicators) are beginning to roll and should, by next year, be part of the scene. These devices permit individual response and feedback within a group. One company has a device which permits program-type questions to be projected automatically by a slide or film-strip projector for student response before or after sequences on a film, film strip, tape, or by a live teacher, thus converting existing materials to a type of programing.

It should be apparent from these trends that the teaching-machine situation is moving in the direction of the greater sophistication demanded by Komoski several years ago. Much of the work is experimental. Problems of marketing, design, reliability, and programing continue to plague this part of the programed-instruction field, and it will be some time before all the dust settles. However, as already noted, some better devices are workable and available.

The great problem programers face, it seems to me, is acquiring the ability to expand from sheer verbal programing, whatever its form, to the creation and management of audiovisual stimulus materials. Programing, up to the present, has been a narrow-band-width, highly redundant means of manipulating information. It has sought (and found, to some extent) efficient means of creating appropriate verbal behavior in human beings. There are dangers in such a narrow approach, dangers of confusing verbal manipulation with reality and understanding, dangers which have been seen by educational reformers since the days of Comenius. Love, wisdom, and skill are rarely obtained from the processing of words, no matter how efficient the behavior. They must be sought in experience. Since experience is hard to come by, the educator must simulate and manipulate it when he can. This is why teaching machines, which never should have been taken seriously as verbal manipulators in the first place, are moving in the audiovisual direction. They represent a means of increasing the communication band-width, of manipulating a little larger chunk of experience. Nothing in this concept diminishes verbal programing, it merely expands the challenge to the programer and makes the oft-quoted statement that books are better than machines completely irrelevant.

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PROGRAMED INSTRUCTION

(Continued from page 1)

visual specialist (or director of educational media) in a position of greater influence in the schools, he will find himself more often, and more effectively, in a position to close the communications gap between the classroom teacher and the behavioral scientist. DAVI, for its part, will continue its efforts to fill the void between the teaching profession and technological developments which can be applied to educational problems.

Although programed instruction holds great promise for education and certainly cannot be viewed as just another audiovisual aid, it is becoming increasingly difficult in schools to separate this particular development from the broader spectrum of instructional technology where work is already under way to present "programed" material on television, to accomplish "branching" through a chain of motion picture projectors, and to reproduce increasingly complex instructional situations in computers. The future of instructional technology in the schools will depend significantly on the rapport and the degree of communication between the scientists who are pushing ahead the boundaries of learning theory and the educational practitioners who are practicing the art of teaching.

ROBERT C. SNIDER
Assistant Director, NEA's Division of Audiovisual Instructional Service; Assistant Executive Secretary, DAVI.

What Can Programed Instruction Offer the Science Teacher?[1]

I assume that most of you reading this article have some degree of familiarity with what Dael Wolfle, in an editorial in *Science* (16 February, 1962, Volume 135, Number 3503) referred to as, ". . . the first major technological innovation in education since the development of printing."

It is not my intention to defend the large number of substandard programs that have flooded the market and will probably continue to do so for much too long a time. Rather, I would like to arouse your interest and enthusiasm for this exciting new development in education and thus, hopefully, hasten the day when there will be available the kinds of programed materials which will be truly welcome additions to your science classroom.

Problems in the Teaching of Science

What is the promise that programed instruction holds for the teaching of science? Let us first identify a few of the more serious problems with which science teachers and their students are coping today. Certainly heading the list is the constantly increasing body of knowledge to be taught. Today's high school science teachers are expected not only to learn more facts but also to develop an understanding of the conceptual framework which gives them meaning.

The increasing emphasis on the laboratory as the place to learn about the scientific process necessitates possession of certain basic skills and scientific knowledge in order to gain the maximum from the experience. This knowledge ranges from relatively simple mathematics to theoretical concepts such as chemical bonding, the paradox of both a particle and wave model for electromagnetic radiation, and the molecular explanation of heredity in living organisms. In addition, the mathematics used for the description of nature by all branches of science should be acquired with some degree of proficiency before entering the science classroom.

Consequently there are, in effect, two separate but related problems that programed instruction can help solve. One is the variety of backgrounds and abilities found in even the most homogeneous group of students. The other is the constantly increasing amount of subject matter to be taught in a relatively brief time (the school year is still about the same length).

For these reasons, two separate but related kinds of programed instruction are needed. One for *remedial purposes,* to correct the deficiencies in mathematics, vocabulary, and general scientific knowledge which handicap the students, and the other for *teaching the specific subject matter* of the course.

Characteristics

What are some of the characteristics of programed instruction which contribute to its effectiveness as a teaching device? One is the rigorous analysis of the subject matter necessary before it can be successfully programed. This involves a clear specification of what is going to be taught and consequently the kinds of skills and knowledge the student is expected to learn. The material must then be presented in a logical and systematic order which insures that as the student proceeds through the program his understanding and mastery are gradually increasing.

A second characteristic of programed instruction is that attention is constantly focused on the critical information to be learned. This can be done in a variety of ways. However, it is largely achieved by requiring some type of response before the student is permitted to go on to the next piece of information. In a branched sequence, *how* a student responds determines what he is shown next. Writing a frame in any programing format so that maximum attention is focused on what is being taught is one of the most inadequately understood and thus, unfortunately, the least successfully accomplished of the programing techniques.

The following sequence is from a program on *The Kinetic-Molecular Theory of Gases.* This particular program had its genesis in an attempt to discover whether programed instruction could be adapted to teach more abstract ideas than had been considered possible. I decided to try to teach high school students something about the nature of theory and law in science, using the kinetic theory of gases and the gas laws as exemplars. (This program has as its prerequisite the *Gas Laws* program or its equivalent.) Examining frames out of context is difficult because it is important to know what came before them. These shown are immediately preceded by an explanation of gas pressure based on the kinetic theory as well as a discussion of the relationship between the absolute temperature and the average kinetic energy of a gas.

Answer	Frame
68 (a) increases (b) less	68 As the temperature of a gas increases, the speed of the molecules (a) ..... This means that at a higher temperature, it would take (b) (less/the same/more) time for a molecule to travel from wall to wall of the container.
69 (a) increase (b) harder than	69 Suppose you could touch the opposite walls of your room ten times a minute by walking back and forth. If you ran as fast as possible from wall to wall, you would (a) (increase/decrease) the number of times per minute you could touch the opposite walls, and you would hit the walls (b) (with the same impact as/harder than) you did when you were walking.
70 (a) faster (b) increases	70 As the temperature of a gas is increased, the molecules move (a) ..... Therefore, the number of collisions per second they make with the container walls (b) .....

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[1]Reprinted from **Science and Math Weekly,** Teacher's Edition, April 10, 1963, Vol. 3, No. 27, by permission of the publisher, American Education Publications, Columbus, Ohio.

When the student errs, the programer flunks. How often we have said this! In the pursuit of excellence in programing, error-free performance was long held as the ideal. For many reasons, programers are changing their attitude toward errors. Errors, formerly the cause for extensive revision, have assumed an important place in the program. Only if the student is given an opportunity to make an error does the programer obtain information on what it is the student needs to learn. Individuals differ in background and ability, and therefore differ in the kind and amount of instruction they need. To find out what a student needs, we need to find out what he knows. So we ask him a question. If he answers correctly, he needs no further instruction on that point; if he does not, some remedial action should be taken. This is the essence of branching programs. Whether the questions be constructed response or multiple choice, whether the frames be long or short, whether the branches occur at every frame or only some frames, the program is a branching program if the student who makes an error at a significant decision point in the program is treated differently from the student who does not.

The occasions for remedial instruction can be conveniently divided into two categories: (a) the student is assumed to know something he does, in fact, not know, or (b) the student is expected to acquire some information at a pace that is too fast for him. The majority of branches in programs can be put into one or the other of these categories by noting a simple structural fact: if the student is asked a question about some subject in which he has not yet been given any instruction in the program, the need for remedial instruction is a function of whether or not he has learned the answer outside the program. If he has learned the answer elsewhere, the program will allow him to by-pass the instruction he does not need. Branches of this type are characterized, then, by a "pretest" question, an erroneous answer to which results in the student being instructed on the point. The other broad category of branching items measures whether the student has adequately grasped some point presented in the program. Structurally, the initial teaching precedes the question. The instruction that follows, if the student makes an error, can be classed as "reteaching," or repetition on a simpler level.

The question arises: how do you locate a faulty branching sequence? Errors on the branching question in the program are no longer an indication that something is awry. The answer, no surprise to programers, lies in an achievement test keyed to the program. In any program, inadequate teaching results in poor test performance. With appropriate design of the test and with a trio of measures of student performance, however, the programer can discover a great deal more about his branching sequence than simply *that* it is faulty. *What* is faulty can be pinpointed. The analysis presented here, modeled on a similar analysis of data from a real program,[1] is given in hypothetical terms in order to simplify the concepts involved.

For the purposes of the model, we make the following assumptions: (a) the behavior measured by the branching question and its related test item is directly comparable; (b) the test items are adequate, and any faults, therefore, lie in the program; (c) the student sample is adequately chosen; and (d) the tests are administered at frequent enough intervals so that later teaching and review have not masked the effectiveness or ineffectiveness of the branching sequences we wish to evaluate. If these assumptions are satisfied (and they rarely are in practice), the effectiveness of the teaching may be measured by tabulating the results from each student on three measures of "the state of his knowledge."

Since there are three measures—pretest, program, and posttest—there are eight possible relationships between the "state of the student's knowledge" at these three points. He may be right (R) or wrong (W) on each of three occasions. A "W" in the third position (wrong on the posttest) is always a significant bit of information, but the programer can learn far more than this. Certain combinations of these rights and wrongs are indicative of specific faults in the design of the program.

Table 1 presents some hypothetical data from twenty students for the case of branches based on lack of information. The pretest, administered before the program, should, obviously, agree with the diagnostic branching question. If the student knows the fact on the pretest, he should know it in the program, and if he does not know it on the pretest, the program should catch him and direct him to the necessary instruction. Thus a good branch of this type must begin with either RR (right on the pretest, right in the program) or WW (wrong on the pretest, wrong in the program). It is hardly necessary to point out that the posttest measure should be R. Item #1 in Table 1 is representative of a good branching question: ten students knew the information and sailed through with an RRR, while ten who did not know it were sent to remedial instruction and learned, resulting in WWR.

Table 1

Error Patterns Based on Lack of Information

	Pretest-program-posttest "state"							
Item:	WWW	WWR	WRW	WRR	RWW	RWR	RRW	RRR
1		10						10
2								20
3		20						
4	14							6
5			10					10
6						14		6

The decision to write a branching sequence is a function of the programer's estimate of individual differences.

[1]The research was supported through the Cooperative Research Program of the Office of Education, Department of Health, Education, and Welfare.

Programers, being human, may be incorrect. Item #2 illustrates a situation which might arise: the programer has provided a branch which no one in his sample needed. All twenty students already knew it. Item #3 illustrates the opposite situation, which could also occur: all twenty students lacked the information, and the remedial instruction ended up in the mainstream of the program, taken by all. Such data raise interesting questions about the representativeness of the sample and the likelihood of running into a deviant pattern elsewhere. The data, clear as they are, do not make the decision for the programer as to whether the branch is worth maintaining despite the pattern of responses it elicited. They do, however, suggest that a decision is required.

The fourth item in Table 1 carries a clear message: *revise*. The question apparently was adequate, since it directed all students who began with a W to the remedial instruction. The effect of the remedial instruction, however, is nil. No student learned anything from it. While real data are never quite as dramatic as this, poor remedial instruction can be located quite easily by too many tallies in the WWW cell.

Item #5 in Table 1 also points to a revision. This WRW pattern is an index of "insensitivity": the student, ignorant on the pretest, was not caught by the question in the program and consequently by-passed the instruction he needed. The data point unequivocally to the need for a more sensitive question in the program. A pattern of this type may easily occur if the test questions are constructed-response questions and the branching question a multiple-choice one. The difficulty may lie, not in the branching question itself, but in the alternatives among which the student is allowed to choose. Answers given on the pretest are a clear indication of what incorrect alternatives must be provided and dealt with. A student with a strong misconception needs to "get it out of his system," and if his preferred answer is not allowed, he may very well learn nothing from being forced to choose a less preferred alternative, even when told he is correct.

Item #6 in Table 1 represents a needless imposition upon students. Although their knowledge is adequate on the pretest, the branching question is worded in such a tricky way that they choose erroneously. An objective appraisal of the branching question will reveal whether this is the case. (In reality, of course, the difficulty may lie in an ambiguous test question, but we are assuming that the test is good and the fault is in the program.)

Several heated arguments may be generated by trying to explain some of the other cells in the table. The pattern RRW indicates an unreliable test question. The pattern RWW should give the programer pause, since it apparently indicates that the student, once knowledgeable, has been misled in the program. The WRR cell may indicate a lucky guess in the program, which was reinforced by confirmation, or a forced choice between one reasonable alternative and other unreasonable alternatives, leading to acquisition without the necessity of extensive remedial instruction.

Where the instruction in the program precedes the branching question, we have a different situation. The reason for branching becomes the necessity for adjusting the pace of instruction to different levels. For simplicity, Table 2 here depends on one further assumption: that the material is new to all students and all tallies begin with a W on the pretest.

As in the "lack-of-information" branch, any tallies in the WWW cell are an instant indication that the programer has failed. The "good" branching frame of this type depends on adequate instruction for many (or most, depending on the programer's predilections) and adequate remedial instruction for the slower students. Item #1 in Table 2 is such an item. Many of the students absorbed the information, answered the branching question correctly, and learned, yielding the WRR pattern. Those who needed more instruction were incorrect, branched to the remedial instruction, and finished the course with an R on the posttest. In contrast, item #2, while adequate for the more rapid learners, left the slower student behind. The difficulty, which calls for revision, is pinpointed in the remedial sequence and its ineffectiveness with the students for whom it was designed.

Table 2

Error Patterns Based on Instructional Pace

	Pretest-program-posttest "state"							
Item:	WWW	WWR	WRW	WRR	RWW	RWR	RRW	RRR
1		6		14				
2	6			14				
3				20				
4		18		2				
5	18			2				
6			18	2				

Again, the tallies may raise the question about the adequacy of the programer's choice of where to branch. In the case of item #3, the remedial track was not needed by anyone. As in the case #2 in Table 1, the programer is left with a decision to make, but the decision involves wasted space or effort rather than misteaching.

Item #4 in Table 2 indicates a remedial sequence that is effective but an initial teaching sequence that fails with most students. If twenty tallies had appeared in the WWR cell and none in the WRR cell, the issue would have been completely clear. In that case the remedial teaching sequence, which works, ought to be made the main teaching sequence. The programer with an 18-2 split should feel encouraged, however. At least there is a workable sequence in his program! For most programers, the tendency to use the remedial teaching as the mainstream frame would probably be strong. In the case of item #5, where too many students fall in the WWW

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USE THE LEARNERS

Because of our rapidly changing world, people have been re-examining subjects as they are now taught in schools. It is generally agreed that learning in all of the disciplines hinges upon actually performing as a scientist, writer, artist, and so on. Basic to performance in the visual arts is the conscious interpretation and use of insightful behavior and creativity. However, performance rests upon an attitude of freedom, which is an expansion of the awareness that there is no right way in art and that divergent thinking is part of creative behavior.

The availability of many subjects and many materials makes possible an unlimited play of the imagination. There are also many styles or ways of organizing a picture. Art depends upon the artist's point of view, his reasons for using a particular art form, and the opportunity he has to express his unique feelings, tastes, interests, and attitudes. Culture and traditions, too, influence performance.

The qualitative aspect of art learning does not lie in information-oriented knowledge such as aesthetics, theories of art, or art history, but in performance. The child learns by behaving as an artist!

By what method can art be taught in the schools better than it now is? Can programed instruction be used to change attitudes and to develop insightful behavior and creativity? If it can do this, how is it structured? These questions came to my mind (I am an art educator) when I first tried to program instruction in art.

I have designed a 95-page (one frame to a page) programed text in art based on the educational intent of changing the picture-making performance of the reader.[1] I limited myself to picture making because of the comparative ease in securing illustrative materials.

The content emphasizes the scope to be found in the graphic arts. Verbal information in the program encompasses the areas of performance, theory, and cultural information. The program style includes both linear and branching sequences.

In determining program content and the structure of frames, I evolved an interacting process based on my knowledge (a) of how an artist acts (I am one), (b) of what children think about pictures and picture making (I worked closely with individual children), and (c) of teaching art (I was a junior high school art teacher).

What did I ask myself at the start? In addition to the many questions common to all programers, I had to discover a point, or points, of reference for myself in art. How do you interest junior high school students in art? Do art forms possess a constant element which can be taught, like principles of design? Is it possible to show examples and use a guided-discovery method? Are there some ideas or terms which cannot be discovered but which must be explicitly presented and taught?

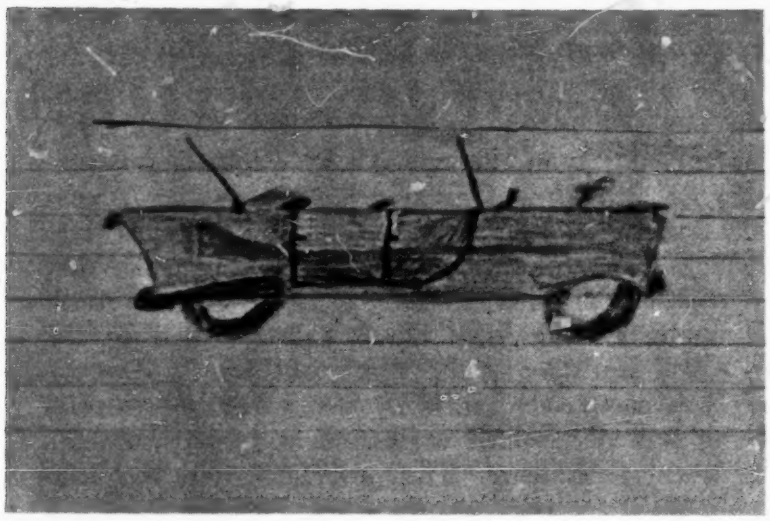
Talking many of these things over with artists and teachers, remembering experiences with students, reading words of artists about visual perception and design, all provided a foundation. I developed about sixty initial frames around three basic concepts: (a) What do you think a picture is? (b) How do you see things? (c) What influences picture making?

The obvious starting point was . . . pictures. Many reasons can be given. Art is nondiscursive The graphic art form depends upon the visual order perceived (the grasping of significant structural patterns) and its impact upon the viewer. The concrete leads to the abstract. The artist's act of searching and scanning includes gathering images, forms, and ideas, and examining his work as it progresses, in addition to making choices among the many possible ideas, media, and dynamic forces of visual imagery.

Among the pictures I chose were photographic visuals of beautiful natural forms. Close-up photography and microphotography were used as well as prints from slides and from children's work. Museums were visited, art periodicals scanned, books and lists of prints consulted. About one thousand visuals were selected. Based on the concept of freedom as an endless variety of style, media, points of view, and visual order, five hundred diverse graphic art forms were selected. Often the choices were made because the originals are in the United States and the learner might see them. Most of the reproductions fell within the twentieth century, reflecting more recent artistic trends.

Many of the decisions about individual frames and the addition or deletion of content were based on spontaneous verbal and written reactions by students during six trials with nineteen learners and with five revisions of materials. Were there any general techniques which remained constant? Yes, two: (a) the use of several visuals in one frame and (b) the use of art materials for a constructed response. For example, five visuals are used in frame 25, which is a double-page spread. At the left are four pictures: Figure 33, a girl using a brayer on a linoleum block; Figure 34, the same girl pressing the block down onto the paper, with a finished print drying on the table above her working area; Figure 35, a photo of a linoleum block, showing gouge marks; and

[1] The attitude of freedom in the program—connoting the widest possible variety of subjects, open ended with the widest possible variety of styles—was tested by a performance problem: "Make a picture. Use any of the materials in Media Box 1." This test was given after the fifth revision and before the final revision. The results were judged for better design by five artist-teachers. The significance level in the matched-pair t test was beyond .05. The learners' "before" and "after" pictures showed visually the change in performance and freedom.



"Pretest": Mike—The constriction and lack of imagination in this drawing of a car should be noted as well as his choice of materials (his own pencil and notebook paper) in spite of the vast array of media and surfaces which were available to him.

"Posttest": Mike—After his experience with the program we can see obvious evidence of greater freedom and initiative in the abstraction and abandon with which the sea, sky, and half-sun are created as well as fire spurting from the cannon and even the vessel's name. The size and definition of the two objects can also be compared.

Figure 36, a print from the same block. On the right, one picture appears below the response verification of the preceding frame. The picture shows the working setup of cutting board, block, and gouges on a newspaper-covered table. Frame 25 discusses print making and the relief process of print making, telling the reader to look at the pictures and asking, among other questions, if he can see the difference between the block and the print. An example of the use of art materials for a constructed response is frame 84. The student is instructed to use a bristle brush and tempera paint on various surfaces and tell what effects are obtained.

The author made her own selection of visuals for the first draft and was largely influenced by her recollection of student comments about displays of contemporary art. After a trial of the initial 65 frames, two seventh graders (a boy and a girl) sorted about three hundred pictures into a dislike group and a like group. The pictures, taken from the original five hundred culled by the author, were composed of photographs of natural forms, children's work, realistic and expressionistic paintings, drawings, and prints. The two youngsters also reviewed the pictures used in the first draft. From the "like" group, the visuals for the revised program were chosen. Neither child had chosen nonobjective pictures, and the investigator arbitrarily included several because they are a contemporary expression in the visual arts.

The illustrations in the first 25 frames of the revised program included realistic and surrealistic paintings, abstract expressionistic pictures, and nonobjective paintings. Most later student reaction to this section can be summed up in Mike's comment during a fourth trial of 120 frames: "Some crazy pictures! Yeah, I like it so far."

A general principle in preparing frames was used; namely, if divergent thinking is the goal, then divergent answers were elicited either visually, by using media, or verbally. If an opinion or belief was involved in the concept, a choice was given of several possible responses, which branched the learner accordingly.

Often the learner constructed answers, using as data information perceived in one of the visuals in that particular frame. Each frame of this style had two or three fill-in sentences. Immediate confirmation for each sentence was not given, but the response to all the sentences appeared at the top of the next frame. (The learners thought that relating the information in the fill-in sentences to the visuals by filling in the number of the pertinent visual made them really see and compare the pictures.) At the end of each section a quiz of five to ten questions was programed into the next as a review. A review summary of things to remember was also included.

Examples of questions designed to elicit divergent thinking are:

1. List the words or word not connected with football.
2. List three ways a pencil may see a piece of paper.

These questions were liked by all nineteen learners. Some wished more such material had been included. Section three, in which these frames occurred, programed divergent thinking about visual perception and was the best-liked section of the text.

One technique used in creating frames was to present a varied visual environment that showed either different portrayals of similar subject matter in a particular art form or similar subject matter in different graphic arts. Here are a few examples: In frame 12, there is a photograph of a landscape in France and a picture by Cezanne of the same landscape. Two paintings of trees are in frame 15, Cezanne's "Trees and Rocks" and van Gogh's "Cypresses." In frame 53 are three visuals with a peacock motif: an Indian miniature painting, "A Musical Mode, Peacocks Attracted by the Sound of the Vina"; Domjan's woodcut, "Peacocks"; and a part of a shopping bag showing a drawing of tail feathers.

A second technique was to display a particular object or experience and then force the learner to take a series of steps that would lead him to a plausible conclusion or that would enable him to describe details of what he has examined. For example, frame 45 deals with texture by having the student rub his pencil over the surface of paper that covers two different textures; the student is asked to examine the two impressions and then to write "how you show texture visually in a drawing, painting, or print."

A third technique was to introduce art terms that appear in literature and in newspapers. This was based on the belief that certain terms about style, design, and art are necessary in a person's vocabulary, even if they do not always appear on children's word lists. Part of frame 28, for example, includes such words as etching, dry point, engraving, and lithography, together with brief descriptions. It was not important to the author that the students be able to spell or recall these terms; rather she felt it necessary to expose the young people to the artist's language. Many of these words were deleted or added in response to student comments.

Man can use whatever he has at hand to create art. Actual art materials were used in constructing some of the answers under the assumption that specific examples would convey to the learner that each surface, applicator, or pigment has qualities which give unique characterisfics to the sensuous expression of an art form. Students reacted favorably to using materials. One boy said that it was stupid just to make initials; he would rather make a block print or a picture. He was given the chance in one frame of a later revision.

During the six trials of the program, the text first expanded to 120 frames and then contracted to 95 frames around the three basic concepts named earlier. Usually error rate and the spontaneous comments recorded during the trial sessions guided the programer in deleting information, adding a branching sequence that made use of more visual material, or changing the texture-defining or picture-making experiments. Whenever a question raised by a student could be answered by the comparison of two or three pictures, new visuals were incorporated. This particular device, the comparison of several pictures, was used often in Section Two, which was concerned with the grasping of significant structural patterns. Section Three was expanded to include patronage of art and some cultural influences, as well as the interdependence of other forces of visual imagery which the artist controls, like space and texture.

The few guides to programing force one, in the discipline of fine arts at least, to use an intuitive approach and to work long hours with individual learners while developing instructional material. Approximately 750 hours were spent evolving this 95-page programed booklet. But the most help in constructing frames came, as already indicated, from working with individual students.

Boredom and fatigue were problems because of the concentrated interacting process the reading and seeing required. Art media experiments seemed logical breaks, and learners said that using art materials broke up the reading "so it made sense."

Other reactions were interesting. The day after he read the introductory section and the first 25 frames concerning "what you think a picture is," David came back to me and said, "Last night my sister and I were fooling around with wax paper and stencils. We tried making pictures." This section showed only one skin stencil of a polar bear and cub made by a Baffin Island artist, Niviaksiak.

In a statement, written at the second stage of revision, Lynn, age eleven, in the sixth grade, summed up much of the learners' reaction to the text. "I liked," she said, "the pictures, the way the words were ecspressed (her spelling). The hard part was understanding the words."

A spontaneous verbal comment from another child indicates the general mood of the children. "Before, I thought you had to paint what you saw, but now I know it's O.K. to change things when you draw," Patty said. "In the other art books, all you saw were pictures after pictures and didn't understand all the words they used. This book was interesting."

A way into programing in the field of art has been opened. This program indicates that behavior in picture making is changed by exercising divergent thinking behavior and divergent figural behavior. These two factors, which contribute to the making of an art form, operate in a permissive atmosphere of freedom. This attitude of freedom is the foundation on which rests the irrational and instinctive behavior involved in creating.

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PI FOR THE SCIENCE TEACHER

(Continued from page 3)

71 harder	71 At higher temperatures when gas molecules are moving faster, they hit their container walls both more frequently and .....
72 increase	72 Therefore, as the temperature of a sample of gas is increased (if the volume is kept the same), we would expect to observe a(n) ..... in the gas pressure.

Even though the statements in this sequence are not difficult, the required responses depend on following the idea being developed, which is that increasing the temperature of a confined gas increases *both* the frequency and force of the molecular collisions on its container walls.

A third characteristic of programed instruction is the essential role of students in the development of a program. This is a special property of programed instruction and possibly the real source of its instruction potential. Through the data collected by observing and recording student responses, a program is revised and improved. In addition, this data can be used to adapt the program to be responsive to the individual differences displayed by even the most homogeneous group. It is possible to individualize programed instruction more than almost any other form of instruction except tutoring. This area in the technique of programing needs to be developed much further.

Programed Homework

How can programed instruction ameliorate the problem which plagues all science teachers of "too much material to cover in one year"? In my opinion, at the high school and college level, programs should be assigned for homework, thus making available the class time usually spent in lecturing on the programed topic. Eventually, it will be possible for most of the fundamental knowledge in all branches of science to be learned by students on their own through programed units and a reference-textbook.

This does not imply that there would be no classroom instruction on the programed topics. However, it should result in more students who are capable of participating in the classroom discussion and understanding the demonstrations.

Unquestionably, the use of programed instruction will create some novel and challenging problems for teachers with respect to course organization. Three years ago, when I embarked on an investigation of the applicability of programed instruction to the teaching of chemistry (supported by a grant from the Carnegie Corporation of New York) this concern influenced the approach I took in designing the programs. For example, I decided to develop each topic in separate, relatively small units, so that teachers would be free to use as many or as few programs as they chose and in any order. I also decided to limit the maximum size of each program so that no unit would take the slowest student more than one calendar week to complete.

To summarize, I shall quote what is in my opinion the definitive answer to the 6.023×10^{23} dollar question, *What does programed instruction do that a good teacher can't do just as well?* This statement is from a recently published highly recommended monograph on Programed Instruction.

"It is obvious that what happens in programed instruction might well happen at a skillfully planned and organized tutorial session, in which the tutor leads the student along, question by question, toward given learning goals. A teacher is an ideal 'teaching machine'; and excellent teaching, if it requires more active responses by the student, employs strategy and tactics which we should call a 'program.' In a sense, teacher training and preparation for classroom teaching is 'programing' the teacher, although much teaching—for example, lecture teaching which minimizes active response from the student—does not make use of the methods of programed instruction. But no one contends that a very skillful teacher could not do whatever a program can do, at least as well as the program can do it—except in one respect; the teacher can tutor only one student at a time." (*Programed Instruction—Today and Tomorrow*, by W. Schramm, may be obtained from The Fund for the Advancement of Education, 477 Madison Avenue, New York 22, N. Y.)

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[For reference data write CPI.]

FAULTY BRANCHING FRAMES

(Continued from page 5)

cell, neither the initial teaching nor the remedial teaching is working well. Extensive revision is indicated.

What of the "insensitivity index," WRW, in this situation? While a pattern such as item #6 may be just that, indicating a too simple question in the program or too strong prompts not available on the test, it may also indicate a perfectly good frame which was not followed by sufficient practice later in the program. In contrast with its message in Table 1, it points less clearly in this case to faulty frame design.

Even though the programer has "taken account of" errors in his program by writing a branching sequence, there is no guarantee that his program will be successful. The posttest provides him with some information. Knowledge of the tracks taken by students through the program provides more. A pretest further increases his information. These three measures, combined with the dual classification of items, based on the reason for branching, maximize the information upon which he may base decisions to retain or revise sequences. The pretest results may help him decide in which classification his branching items belong: a large number of R's on the pretest in Table 2 might indicate that the instruction need not precede the question, while a large number of W's on the pretest in Table 1 might indicate a faulty assumption about what instruction most students in his population require. Without the pretest, the programer has no way of distinguishing between "trick" questions (at item #6 in Table 1) and good remedial teaching. It hardly needs emphasizing that the information lost to the programer who does not measure what his students do in the program is considerable.

In dealing with real data from real students taking a real program, the decisions are not as simple as this model may indicate, because the information on which the decisions are based is not so neatly categorized. A faulty teaching sequence, combined with a faulty test item, may lead to tallies distributed in every cell. But in many cases, the trends in the data are quite clear. The programer who wishes to perfect his branching program does not have to depend on intuition.

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CPI ANNOUNCES WORKSHOPS

The training division of The Center for Programed Instruction has announced a full schedule of workshops for individual enrollment for this Fall and early 1964. They are:

Introduction to Program Writing and Editing

November 11-22, 1963
January 6-17, 1964
March 9-20, 1964
May 11-22, 1964

Advanced Programing

December 2-13, 1963
February 17-28, 1964
April 13-24, 1964

These workshops will be conducted at the Center's training facilities in New York, Monday through Friday, 10 a.m. to 4 p.m., during the periods indicated.

Introduction to Program Writing and Editing will also be offered during late afternoon or early evening sessions twice weekly for ten weeks beginning November 25. Exact days and hour will be decided upon shortly.

Individuals who are interested in enrolling in these workshops should write for further information about curriculum, faculty, and costs to Robert E. Horn, Director, Training and Consulting Services, The Center for Programed Instruction, 365 West End Avenue, New York 24, New York.

Organizations that wish to have a CPI workshop tailored to their special needs should write to Mr. Horn for further information. In the past such workshops have included in-service sessions for teachers and school administrators, introductory program writing and editing, and advanced programing.